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Antarctic Ozone Decrease: Possible Impact on the Seasonal and Latitudinal  
Distribution of Total Ozone as Simulated by a 2-D Model

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Satellite borne instruments (TOMS and SBUV) show that total column ozone has decreased by more than 5% in the neighborhood of 60°S at all seasons since 1979. This is considerably larger than the decrease calculated by 2-D models which take into account solar flux variation and increases of trace gas concentrations over the same period. The meteorological conditions (warmer temperature and the apparent lack of polar stratospheric clouds) at these latitudes do not seem to favor heterogeneous chemistry as the direct cause for the observed ozone reduction. A mechanism involving the seasonal transport of ozone-poor air mass from within the polar vortex to lower latitudes (the so-called 'dilution effect') is proposed as a possible explanation for the observed year-round ozone reduction in regions away from the vortex.

Observations indicated that the column content of O<sub>3</sub> within the antarctic polar vortex decreases by about 50% during the austral spring. This amount corresponds to about 4% of the global content of O<sub>3</sub>. Following the break down of the vortex in October, the O<sub>3</sub> content in the region is observed to recover within a few weeks. Given that the photochemical replacement time of O<sub>3</sub> at such latitude is estimated to be longer than a season below 25 km, the rapid filling-in of the O<sub>3</sub> hole can only be achieved by transport of O<sub>3</sub> from the mid-latitude region and mixing of air masses between the two regions. The assumption that spring O<sub>3</sub> decrease within the vortex is due to removal by photochemical processes raises the question of whether the subsequent redistribution of O<sub>3</sub> to fill the hole can affect the global O<sub>3</sub> content on a year long basis.

The extent and the persistence of the global impact will partially depend on the ability of the atmosphere to compensate for the antarctic loss by photochemical adjustment. The photochemical replacement time for  $O_3$  in the upper stratosphere is a few days, i. e. the concentration of  $O_3$  in the upper stratosphere would recover to its normal value within a few days if the  $O_3$  were perturbed. Thus, if the  $O_3$ -poor air is exported to and replaced by  $O_3$ -rich air imported from the upper stratosphere, the impact on global content should be minimum. However, if the  $O_3$  hole is to be filled by mixing with air from the lower stratosphere, where the photochemical replacement time ranges from a few months to a year, the photochemical compensation may not be complete within the year before the recurrence of the  $O_3$  hole in the next spring. Using a 2-D model, we show that dilution could contribute to a year-round decrease of  $O_3$  outside the polar vortex.

Although present 2-D models are not designed to simulate the formation and evolution of the polar vortex, they can be used to assess the global impact of the  $O_3$  redistribution on a seasonal time scale. We modify the circulation in the 2-D model to simulate the vortex by preventing exchange of air across the boundary of the vortex between 14 and 22 km from mid-April to the end of October. Instead of actually putting in detailed heterogeneous chemistry to simulate the  $O_3$  removal, we simply remove an additional amount of  $O_3$  within the vortex right during the time the barrier is in place.

Our model results showed that

- the dilution effect could be a major contributing factor to the observed year-round decrease of total  $O_3$  between  $40^\circ S$  -  $60^\circ S$ . The impact is, however, small for latitudes north of  $30^\circ S$ .
- the time constant of ozone associated with the dilution effect is relatively short, of order 1 year. This means that the dilution impact is essentially non-accumulative.
- the magnitude of the  $O_3$  change is sensitive to the value of  $K_{yy}$  adopted in the model calculation.